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International Research Collaboration: Contemporary Trends and Trajectories from GCC Countries

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Abstract

There has been a phenomenal increase in the mobility of researchers and research-students between Gulf Cooperation Council (GCC) countries and the rest of the world. However, this emerging phenomenon remains largely under-researched. Drawing on empirical examination, the paper provides insights into ongoing international research collaboration in the Gulf region. The context is examined using bibliometric studies to analyse published research outputs from contemporary Standard International Database (Scopus) for the period 2004 to 2013. The findings revealed that USA is the most paramount research collaborating country. Simultaneously, Egypt is the second most important country and the only nearest neighbour of the top fifteen countries with which GCC countries collaborate with, whilst other countries follow with significant differences. Additionally, GCC countries' international research collaboration focuses mainly on the academic arena of physical sciences followed by life sciences with compelling variations.

Keywords: *research policy, international research collaboration, academic research, academic disciplines, GCC countries.*

1. Introduction

In recent decades there has been remarkable increase in research collaboration and mobility of both researchers and research-students across the globe (Boekholt et al., 2009) and extended to continents that research collaborations

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[2]Current GCC member states are the following countries located in the Arabian Peninsula: Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and UAE.

were hitherto unknown or hardly existed (Kim et al., 2017). This is driven by the desire to find ways to solve societal challenges that have "global implications including climate change, anti-microbial resistance, pressure on resources such as food, water, and raw materials" (Ulrichsen and Featherston, 2016:1). The increase in international collaborations among academic researchers has become a key dimension in the strategic considerations of governments, funding bodies, research institutions, and researchers (Boekholt et al., 2009). The motives behind this trend are many, ranging from simply seeking advice in a specific research area to gaining access to resources such as funding, instruments and national data. For the individual researcher, the ultimate aim to collaborate is to gain knowledge, enhance research quality and career advancement not relinquishing increase productivity. At the national level, the motive is to maximize national competitiveness and solve complex international research problems.

Studies on collaborations have examined a wide variety of factors and dynamics (Shrum et al., 2007) aimed at finding solutions to fundamental human concerns (Handley, 2011). This notwithstanding, individual academics and higher education institutions have engaged with their international colleagues in collaborations, some of which have resulted in the joint publication of research findings. Universities these days emphasize the need for not only publications per se but international collaborations as well (Luukkonen et al., 1992). Besides academic advancement, academics sustain and broaden their influence through intellectual discourse across networks and the exchange of publications, and in reports and conferences as well (Davies, 1995).

Empirical literature on international research collaboration in higher education abounds (Tight, 2007; Kim et al., 2017), but it is believed researches in the GCC countries are lagging behind (Farhat et al., 2013; Zyoud et al., 2014). Surprisingly, no known study is readily available regarding international research collaborations in higher education within the Gulf region; the closest is the contribution of Arab researchers to ophthalmology (Sweileh et al., 2015). This study aims and attempts to fill this lacuna by focusing on international research collaborations in GCC countries with the goal of examining these collaborations with the top fifteen most prominent collaborating countries between 2004 and 2013. We sought to answer the following research questions: What are the main characteristics and trends of research collaboration among the GCC countries and their top 15 collaborators? What is the pattern of this research collaboration among GCC countries and at what academic discipline are these collaborations? To answer these questions, we used the number of international co-authored papers in GCC to ascertain the impact of research collaboration (Chinchilla-Rodríguez et al., 2012; He, 2009; Katz and Martin, 1997). Researchers also use acknowledgements (sub-authorship) as a second

indicator (Cronin, 2005) especially when not all collaboration results in ultimate co-authored publications. Further, scholars use citation rate of international co-authored papers to measure the quality of international collaboration (Levitt and Thelwall, 2010) because the rate of citation for internationally co-authored papers appear higher than single-authorship or nationally co-authored papers. These also tend to be published in high-impact journals and have higher visibility through conferences (Levitt and Thelwall, 2010; Persson et al., 2004). In addition, studies have proven that collaborative research results in positive impacts on countries, institutions and individual researchers as well in terms of productivity (Abt, 2007; Duque et al., 2005; Beaver, 2001).

The paper is looked at through the lens of social interdependence theory which requires the collaboration of members of a group to solve complex societal problems (Lee et al., 2015; Bell, 2010). The paper contributes to empirical literature by bringing the region's perspectives of international collaboration in higher education to the fore. Hitherto, the region has been known because of its wealth in oil reserves and natural energy (OPEC, 2016). Thus, the findings would provide valuable insights into planning and managing research collaborations, establishing links between and among GCC countries and beyond and equally serving as a reference point. The rest of the paper is structured as follows: the next section presents a brief theoretical overview of international research collaborations and the social interdependence theory. This is followed by the methodology. The results and discussion of findings are subsequently presented. The findings and conclusion suggests the regions' collaborations focuses mainly on physical science disciplines, followed by life sciences before the arts and humanities disciplines. The USA and Egypt are the topmost collaborating partners of the region.

2. Theoretical Review of Literature

2.1 International Research Collaborations

Collaboration, not overt competition, has become a catchword in the international arena. Countries need to be interdependent on each other and consequently call for international collaborations. Research collaborations have become inevitable in the development of nations. Boekholt et al., (2009) have reported that the last forty years have witnessed an unprecedented emergence and growth of international collaborations. This has been necessitated by the need to resolve issues related to climate change, diseases, cyber security, terrorism, food and water security and other concerns (Boekholt et al., 2009; Ulrichsen and Featherston, 2016; Handley, 2011). International research collaborations are research projects that involve investigators whose primary

employment affiliations are in different countries (Anderson, 2011:3). Within higher education institutions, collaborative research is widely promoted to break-down barriers between universities and industry, commerce, government and public services (Smith and Katz, 2000). This occurs at individuals, groups, departments, institutions, sectors and countries levels (Smith and Katz, 2000) and could be formal or informal. Collaboration provides the means to both professional advancement and increased knowledge. It also offers access to resources (both information and equipment) and association with the scientific community (Luukkonen et al., 1992). The incentive to collaborate is mostly influenced by the maxim 'publish or perish' (Luukkonen et al., 1992). These notwithstanding, international research collaborations are affected by many factors including the country size, academic disciplines, geography, politics and language (Jeong and Choi, 2014; Davidson Frame and Carpenter, 1979). Collaborations occur more in basic research as compared to applied research (Katz, 2000; Davidson Frame and Carpenter, 1979) and is influenced by socioeconomic and cultural ties (Boekholt et al., 2009).

2.2 Social Interdependence Theory

We used the Social Interdependence Theory (SIT) because it provides conceptual understanding of cooperation in groups (Lee et al., 2015; Parolia et al., 2011) and has been applied extensively in education, business and service organizations (Johnson and Johnson, 2003) to promote the development of collaborative skills, improve critical and creative thinking, aid complex problem solving, and transfer positive attitudes towards tasks (Johnson and Johnson, 1989; Bell, 2010; Lee et al., 2015). The theory relies on the interdependence of members of a group to achieve common goals. Social interdependence exists when the accomplishment of one's goals are affected by the actions of others (Deutsch, 1962; Johnson and Johnson, 1989; Johnson and Johnson, 2003). Literature has shown two main types of social interdependence, positive (cooperation) and negative (competition) interdependence. Positive interdependence exists when individuals perceive that they can reach their goals only if other individuals with whom they are cooperatively linked also reach their goals thereby promoting each other's efforts to achieve the goals (Johnson and Johnson, 2003; Johnson and Johnson, 2009). Negative interdependence on the other hand exists when individuals perceive that they can only obtain their goals if other individuals with whom they are competitively linked fail to obtain their goals. They deliberately impede each other's efforts to achieve the goals (Johnson and Johnson, 2009). Positive interdependence results in effective collaboration with beneficial outcomes such as "mutual help and assistance, exchange of needed resources, effective communication, mutual influence, trust and constructive management of conflict" (Johnson and Johnson, 2005:936) as well as cohesion,

esprit-de-corps, and social support (Johnson and Johnson, 2009). Negative interdependence results in divergent perceptions of the same situation, goal incongruence, conflicts, resistance and unnecessary delays (Kazanjian et al., 2000; Parolia et al., 2011).

The SIT fits very well with international research collaborations because social interdependence facilitates the pulling of cultural, relational and material resources together to promote not only collegial support but improve research innovation and conceptual framings for practice (Drew et al., 2016) as well as transfer new ideas and techniques from one place to the other (Johnson & Johnson, 2008). SIT would therefore lead to higher achievement and productivity (Johnson & Johnson, 2008). Individuals, who hitherto could not achieve more, would achieve tremendously under SIT when they work collaboratively (Johnson & Johnson, 2005). There is therefore the 'power of unity' in collaboration to achieve much.

2.3 Propositions

Based on the review of literature, the following propositions are being investigated:

Proposition 1: Collaborative research increases research outputs of GCC countries.

Proposition 2: Research collaboration tends to take place between GCC countries and mostly economically and technologically advanced countries.

Proposition 3: Research collaboration between the GCC countries and the collaborating countries is mostly concentrated in the science disciplines (health, life and physical sciences).

3. Methodology

The GCC is a regional political organisation comprising the energy rich Gulf monarchies of Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates. The GCC was set-up to boost economic cooperation between members, guard against threats from neighbouring states and establish scientific research amongst others (GCC, 2014). The countries share similar political, social and cultural ideologies. Saudi Arabia is the most influential member of the alliance, the largest and richest of the six and this is followed by UAE. Collectively, GCC countries possess almost half of the world's oil reserves and about 23% of global natural gas reserves (OPEC, 2016). Most of the higher education institutions in the region are private sector-driven but depends more on government assistance

(Hertog, 2014), while others are affiliated to international universities. Most of the region's research output is produced by academics in the universities and research centres. These researches are mainly published in international journals listed in the Scopus database. However, few of the published researches (mainly from humanities and social science disciplines) are written in Arabic, and are therefore not included in the Scopus database. The main indicator used in measuring international research collaborations is research that has one or more co-authors from a different country.

The authors used bibliometric analysis to examine international research collaboration within the region. This involved the use of statistical methods to extract the key research indicators from the SciVal software derived from the Elsevier Company's web-based digital solutions (Elsevier Research Intelligence Suite). SciVal uses content from the Scopus database from 1996 onwards. Among the research inputs in this software are articles, reviews, conference papers, editorials, and short surveys, which are updated weekly. In some few instances, the authors directly used the online Scopus database for some key indicators.

We extracted publications emanating from GCC countries from 2004-2013 and selected the international research collaborations within the same period. The criteria used were that at least one address of the collaborating authors should come from one of the GCC countries, and at least one from the top fifteen countries. The publications that had more than one address from each of the fifteen countries were allocated to each of these countries. Data collected were then used to generate information on international research collaboration between GCC countries and the most collaborative countries, and the academic disciplines that these collaborations came from. Publications have been used to categorize the most productive and cited authors in higher education research (Budd and Magnuson, 2010; Kim et al., 2017). In this study, the total number of publications from the GCC countries was 105,974, showing an overall growth rate of 15.6% from 4,676 publications in 2004 to 22,188 in 2013. These are expatiated in the next section.

4. Results, Discussion and Examination of Findings

Data for this section was derived from SciVal. Table 1 below illustrates the yearly research output of all GCC countries from 2004 to 2013. During this period, GCC countries produced a total of 105,974 publications, with KSA producing the most (59,854), and Bahrain producing the least (2,964). The significant variance is probably due to the size and number of research institutions in each country. For example, KSA has twenty-five public funded universities whereas

Bahrain has only one where almost all the research outputs are generated. This corroborates research preposition 2. The size, reputation, employability and history of the research institutions of the GCC countries are beyond the scope of this paper. We only examined the annual growth rate of research collaborations in these countries.

Table 1: Annual Research Output of GCC Countries from 2004-2013

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total
Bahrain	196	238	272	267	277	307	325	341	314	427	2964
Kuwait	764	862	932	965	1089	1145	1141	1239	1266	1307	10710
Oman	432	494	550	601	621	752	900	1089	1151	1227	7817
Qatar	205	264	293	420	545	627	808	953	1305	1807	7227
KSA	2265	2382	2578	2771	3245	4308	6263	9405	12005	14632	59854
UAE	906	1206	1407	1422	1656	1950	2331	2674	3064	3261	19877
GCC	**4676**	**5349**	**5888**	**6292**	**7230**	**8879**	**11492**	**15325**	**18655**	**22188**	**105974**

Source: Elsevier B.V. SciVal (2014), a registered trademark of Elsevier Properties.

In terms of annual percentage growth of research, KSA has the highest, reaching its peak in 2011 at 50%. However, this trend decreased to 28% and 22% in 2012 and 2013 respectively. Oman and UAE also increased their research output from 2009 to 2010 but with a significant decrease in 2012 and 2013. Bahrain, despite the significant decrease in 2012, showed a higher growth rate of research output up to 35.37% in 2013. Kuwait showed increases in 2005 and 2008 at 13% and a decline in the rest of the years. Qatar had oscillating annual growth rates up-to 2011, but remained fairly stable at approximately 37% in 2012 and 2013. Generally, GCC countries' overall growth rate peaked in 2011 with 33.88%. However, this subsequently dropped in 2012 and 2013. In annual percentage terms, GCC countries demonstrated a continuous decrease in their research outputs from 2011 to 2013 despite the fact that in quantitative terms, their research output was increasing. This is depicted in Table 2 below;

Table 2: GCC Countries Growth Rate of Research Productivity for 2004-2013

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total
Bahrain	-	21%	14%	(2%)	4%	11%	6%	5%	(8%)	36%	7.8%
Kuwait	-	13%	8%	4%	13%	5%	0%	9%	2%	3%	5.4%
Oman	-	14%	11%	9%	3%	21%	20%	21%	6%	7%	10.4%
Qatar	-	29%	11%	43%	30%	15%	29%	18%	37%	38%	21.8%
KSA	-	5%	8%	7%	17%	33%	45%	50%	28%	22%	18.7%
UAE	-	33%	17%	1%	16%	18%	20%	15%	15%	6%	12.8%
GCC	**-**	**14%**	**10%**	**7%**	**15%**	**23%**	**29%**	**33%**	**22%**	**19%**	**15.6%**

Source: Elsevier B.V. SciVal (2014), a registered trademark of Elsevier Properties.

Following Table 2 above, we looked at international collaborations that resulted in publications between GCC countries and international collaborators in the SciVal software. The data showed there was tremendous increase in international research collaboration within the period under consideration. For instance, in 2013, 14,404 out of 22,188 publications were as a result of international collaborations. This represented 65% of 2013's research output. The total number of research output in 2004 was 4,676 and out of this number 1,786 were products of international collaborations. This also represented 38% of the regions research output. From 2004–2013, in terms of individual member countries, Qatar was the most internationally collaborative country (66% of her publications) while Kuwait was the least collaborative country with 41% of her publications. This confirms that SIT has beneficial outcomes including "mutual help and assistance, exchange of needed resources…" which eventually leads to increased productivity (Johnson and Johnson, 2003:936). This corroborates proposition 1. Table 3 below presents data on the number and percentage of international collaboration for 2004 and 2013 for the GCC countries.

Table 3: Two Year's Percentage of GCC Countries International Collaboration

Country	2004			2013		
	Total Publications	International Collaboration	International Collaboration (%)	Total Publications	International Collaboration	International Collaboration (%)
Bahrain	196	80	41%	427	232	54%
Kuwait	764	220	29%	1307	585	45%
Oman	432	190	44%	1228	700	57%
Qatar	205	89	43%	1807	1398	77%
KSA	2265	688	30%	14632	9774	67%
UAE	906	460	51%	3261	1904	58%
GCC	**4676**	**1784**	**38%**	**22188**	**14404**	**65%**

Source: Elsevier B.V. SciVal (2014), a registered trademark of Elsevier Properties.

Various reasons accounted for the positive growth in research productivity in the region. One of such was the introduction of funding programs and other strategies especially from 2005 onwards. For instance, in KSA most of the publicly-funded universities received funding packages for research and this made them become dominant research producers. The University Research Fund (URF) Program in King Abdullah University of Science and Technology (KAUST) established in 2007 is a typical example. The URF provided academic researchers in the university seven different funding opportunities (KAUST, 2016). In Qatar, the Qatar Foundation (QF) also established the Qatar National Research Fund (QNRF) in 2006 to provide funding opportunities for researchers to enhance research, improve innovation and technological capacity. In addition, the QF also entered into partnership with other foreign universities and this led to the establishment of eight satellite campuses in QF campus (Virginia Commonwealth University, Weill Cornell Medical College, Texas A&M University, Carnegie Mellon University, Georgetown School of Foreign Service, North-Western University, HEC Paris, and University College London). These partner universities further played a vital role in the national research productivity of Qatar, the regions' research output and beyond through collaborations with other researchers, especially US-based research institutions.

In UAE, the National Research Foundation (NRF) was also established to provide funding for not only private and public universities but also colleges through the introduction of different funding schemes to increase research productivity. Public universities in the UAE including the UAE University, the

American University in Sharjah and the University of Sharjah have allocated substantial amounts of resources to enhance research productivity of faculty members. The University of Sharjah provides grants for conducting collaborative research overseas during the summer break. Finally, The Research Council (TRC) was established in Oman somewhere in the mid-2005 to be Oman's exclusive research funding body to support and promote research activities. TRC launched about thirteen different funding programs including the Open Research Grant Program (ORGP), the Strategic Research Grant (SRG), and the Research Chairs Program (TRC, 2017) to enhance research productivity. These programs, it is believed, led to the remarkable improvement in research output in the region especially during their first five years of inception. These reasons support the proposition that collaborative research increases research output. Despite these gains, the region suffers from institutional and national level bureaucracies related to managing and funding research activities as well as insufficient allocation of funds for collaborative research.

Data in Table 4 below shows the top fifteen countries with which GCC countries have collaborated. These countries are located across the globe and are: United States (US), Egypt, United Kingdom (UK), Canada, India, Germany, Malaysia, China, France, Pakistan, Australia, Italy, Turkey, Spain and South Korea and thus, supporting Preposition 2. The US is the topmost collaborative country with joint research output up to 12.7% and followed by Egypt with 9.9%. It is important to note that Egypt is the only country from the Arab World that falls within the top fifteen international collaborative countries and outside the Gulf region. Although ranked second, Egypt's main collaborator is KSA and not with the other GCC countries, since it is ranked fourth for Qatar and UAE, and seventh for Oman. UK and the rest of the top fifteen countries follow suit with great variations. The least collaborative country is South Korea with 1.1% output.

The volume of GCC's research collaboration with the US is attributed to the fact that US is the top research-intensive country in the world, and researchers across the globe collaborate with her researchers to achieve excellence, attract scarce human resources, and build national science and technological capabilities. In addition to that, Bozeman and Corley (2004) argue that researchers select their collaborators based on factors such as language and nationalities, opportunities to seek research experiences, supporting younger colleagues, and others prefer collaborating with researchers they have previously worked with. Most GCC-based researchers completed their PhD degrees in US, UK, and Canada, which explains why these three countries are among the topmost collaborative countries.

Moreover, many researchers from the top fifteen collaborative countries work in higher education/research institutions in GCC where they either collaborate with colleagues back home or introduce them to local researchers in these institutions. Besides, within the Arab world, Egypt is the highest research producing country and some Egyptian researchers work in higher education in GCC. Notwithstanding, some GCC researchers also pursued their PhD degrees in Egypt (humanities and social sciences) and still maintain research collaboration ties. These arguments support Bozeman and Corley (2004) view that researchers collaborate with colleagues and those with whom they worked during their studies.

As earlier indicated, it is worth noting that some GCC countries have attracted the opening up of foreign university campuses by providing the needed logistics. As indicated earlier, Qatar alone has eight satellite campuses. These universities encourage research collaboration with their home countries, and have cascaded the total research publications to twenty-fold increase between 2004 and 2013. Similarly, the UAE has also attracted the establishment of foreign based higher education/research institutions. This explains why US is the main research collaborative country with Qatar, UAE and the Gulf region. To compliment these, some GCC higher education institutions are also affiliated with universities in UK, France and Canada. These revelations support preposition 2 that research collaborations takes place between GCC countries and most economically sound and technologically advanced countries.

Table 4: GCC Research Publications with the Top Fifteen Collaborative Countries from 2004-2013

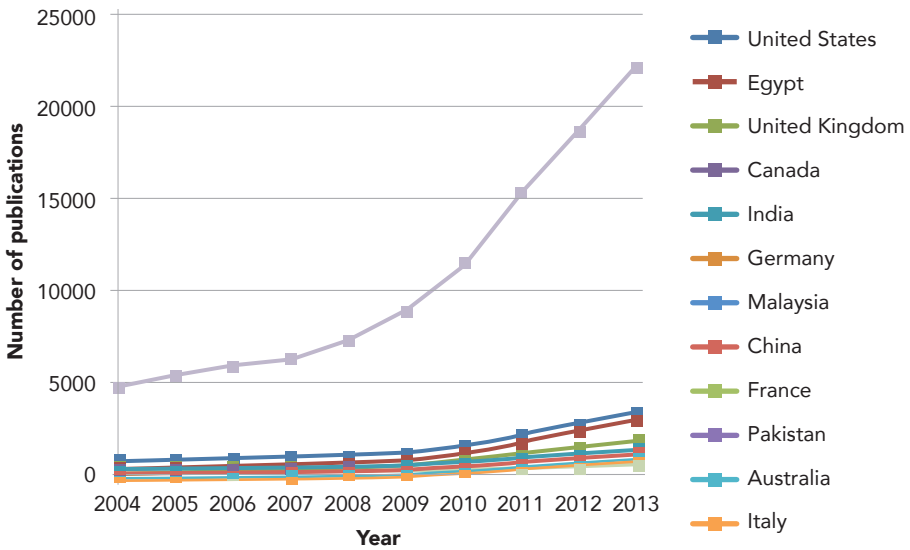
Country	Country Location	Number of Collaborative Publications	Share of Total GCC Output (%)
United States	N. America	13427	12.7%
Egypt	Arab World	10494	9.9%
United Kingdom	Europe	6846	6.5%
Canada	Canada	4934	4.7%
India	Asia	4393	4.1%
Germany	Europe	3251	3.1%
Malaysia	Asia	2582	2.4%
China	Asia	2495	2.4%
France	Europe	2788	2.6%

Country	Country Location	Number of Collaborative Publications	Share of Total GCC Output (%)
Pakistan	Asia	2337	2.2%
Australia	Australia	2500	2.4%
Italy	Europe	1635	1.5%
Turkey	Europe	1466	1.4%
Spain	Europe	1288	1.2%
South Korea	Asia	1214	1.1%
Total Share		**48662**	**46%**

Source: Elsevier B.V. SciVal (2014), a registered trademark of Elsevier Properties.

In order to better conceive the pattern of international collaboration with the top fifteen collaborative countries, we examined the publications patterns of these collaborations over the period 2004-2013. As illustrated in Figure 1 below, GCC countries showed a rapid increase in their research publications. Simultaneously, GCC also showed a rapid increase in their research collaboration patterns with the top fifteen collaborative countries. This reveals that the growth of GCC countries publications for the ten years also had an impact on academic collaboration. Consequently, the growth of international collaboration with the top fifteen collaborators was significantly high.

Figure 1: Growth Patterns of Publications and International Research Collaboration between GCC and their Top Fifteen Countries



We made this comparison by producing the exponential function model of publications in GCC countries and region's collaboration with her top fifteen collaborators as shown in Table 5 below. The formula we used was:

$P(t) = Poe^{rt}$

P(t) = the amount at time t r = the growth rate Po = initial amount at time t = 0
t = time (number of periods, i.e. 1,2,3,4,5), where the year 2005 corresponds to t=1

Table 5: Exponential Function Model of International Research Collaboration between GCC Countries their Top Fifteen Collaborating Countries

Countries	r	Po	P(t)
United States	21.62%	466	3263
Egypt	26.10%	302	3169
United Kingdom	18.00%	293	1481
Canada	19.50%	182	1054
India	26.00%	109	1131
Germany	26.66%	72	796
Malaysia	40.40%	19	718
China	38.60%	26	840
France	25.30%	67	652
Pakistan	31.00%	38	620
Australia	25.85%	64	656
Italy	27.41%	44	517
Turkey	24.55%	50	457
Spain	31.50%	24	408
South Korea	40.80%	10	395
Top 15 Countries	23.57%	1489	12419
GCC	**17.30%**	**4676**	**22188**

In We observed the growth rate of GCC research collaboration with the top fifteen collaborators is quite high; however, this varies from country to country. For example, the growth rate of research publications with India and Germany is higher than that of UK and Canada. Additionally, we also observed the growth rate of collaborations between GCC countries and all fifteen collaborating countries (see r values of each country or r value for all top 15 countries) was consistently higher compared to the growth rate from only GCC countries' (23.57% for top fifteen countries compared to 17.3% for GCC).

In addition, we realised that collaborations with South Korea, Malaysia and China are highest (40.8%, 40.4%, and 38.6% respectively) while collaborations with UK, Canada, and US are the lowest (18%, 19.5%, and 21.6% respectively). This might be due to fact that research productivity of these countries showed a massive increase during the last ten years. For example, Chinese research output has witnessed significant increase since 2004, in quantity from 177,878 in 2004 to 750,368 in 2013 (WoS, 2015) and world share, where China is ranked fifth largest research producing country after the US, Japan, UK, and Germany (He, 2009; Wu et al., 2004).

Figure 2: Growth of Publications in the Top Fifteen Collaborative Countries with GCC

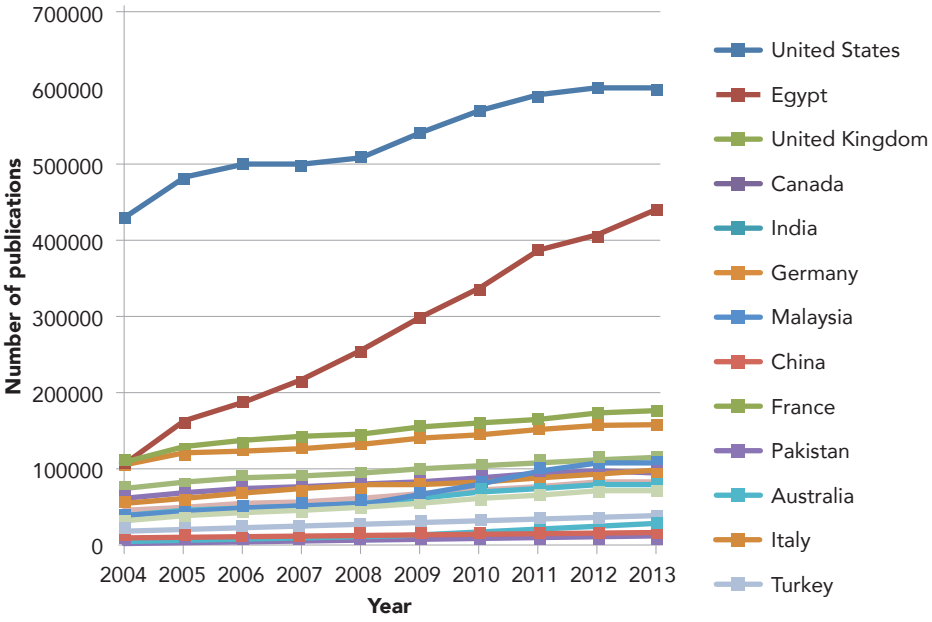


Figure 2 above shows the annual growth rate of research output for the top fifteen countries. The figure shows slow linear growth for all the countries except for US and China. This suggests that the reason behind the growth of international collaboration with the top fifteen countries was due to the rapid growth in GCC research output during the last decade. The US is the main collaborative country for GCC, and its research output is far ahead of other countries. Similarly, China's research output has grown rapidly since 2004 compared to other countries, which may explain why the growth rate of Chinese-GCC collaboration is one of the highest rates compared to other collaborative countries.

5. Strength of Collaborations' Relationship and Variance

It is significant to examine whether or not the research output of GCC countries has a relationship with the countries' research collaboration with the top fifteen collaborators. Additionally, it is important to understand how much variance in the GCC's research output is explained by each of the international research collaboration.

5.1 Correlations

Table 6 below shows Pearson's (r) correlation of the international research collaboration between GCC countries and the top fifteen collaborative countries for the period 2004-2013. Pearson's (r) correlation between GCC countries and all top fifteen collaborators is more than 0.95. For example, Pearson's (r) correlation values between GCC countries and the US and Egypt are 0.998 and 0.986 respectively. This implies there is an almost perfect positive relationship between GCC countries and the top fifteen collaborators as the Pearson's (r) quantities are very close to 1 (Mukaka, 2012). Additionally, as p≤ 1% we reject the null hypothesis and argue that the correlation between GCC countries and each of the top fifteen collaborators is not due to random sampling and that the variables are statistically significant (Pallant, 2001).

Table 6: Inter-Correlation Matrixa

Countries	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.
GCC															
United States	.998**														
Egypt	.986**	.993**													
United Kingdom	.998**	.999**	.989**												
Canada	.995**	.991**	.972**	.994**											
India	.996**	.994**	.980**	.994**	.996**										
Germany	.994**	.992**	.975**	.994**	.998**	.997**									
Malaysia	.966**	.964**	.947**	.965**	.978**	.983**	.984**								
China	.990**	.995**	.996**	.992**	.984**	.991**	.987**	.971**							
France	.998**	.994**	.975**	.996**	.997**	.994**	.994**	.964**	.983**						
Pakistan	.995**	.990**	.976**	.990**	.995**	.998**	.993**	.980**	.988**	.992**					
Australia	.993**	.995**	.991**	.996**	.985**	.984**	.985**	.949**	.990**	.990**	.981**				
Italy	.979**	.988**	.996**	.985**	.968**	.971**	.971**	.939**	.992**	.970**	.967**	.992**			
Turkey	.974**	.985**	.997**	.979**	.960**	.971**	.966**	.944**	.994**	.961**	.966**	.982**	.994**		
Spain	.989**	.995**	.991**	.992**	.983**	.989**	.987**	.961**	.994**	.985**	.982**	.990**	.989**	.987**	
South Korea	.994**	.998**	.994**	.995**	.989**	.993**	.991**	.970**	.999**	.989**	.990**	.992**	.991**	.990**	.997**

[a]n=10

p≤.01

5.2 Linear Regression

Furthermore, we ran linear regression by setting the research output of GCC countries as the dependent variable, and the output from each of the top fifteen research collaborators as the independent variables. Table 7 below shows that R^2 equals 0.999. This means the almost perfect model (99.9%) explains the variance in the research output of GCC countries. Additionally, it is confirmed that the research collaboration of GCC countries with the United States significantly contributed to the GCC countries research output (beta= 1.513), followed by Canada (beta= 0.580) and Turkey (beta= 0.417).

Table 7: Results of Linear Regression for GCC Research Output

Variables	
United States	1.513
Egypt	-.185
United Kingdom	.300
Canada	.580
India	.043
Germany	.024
Malaysia	-.161
China	-.310
France	-.058
Pakistan	.230
Australia	.167
Italy	-.314
Turkey	.417
Spain	.047
South Korea	-.321
R^2	.999
Adjusted R^2	.998
N	10

Moreover, we determined the regression equation as: yi= bo + b1xi. In Table 8, the constant (b) and the b1 coefficient (slope) are presented. Our regression model will be different for each of the collaborative countries. For instance, for the collaboration with the US, it will be:
yi= 2111.428+ (6.320xi)

In the above equation, *xi* represents the units of the international research collaboration of GCC countries with the US and *yi* the amount of the increase in the GCC countries' research output when xi changes. Our regression model for the rest of the countries follows the same pattern.

Table 8: Constants and Slopes

Country	bo	b1
United States	2111.428	6.320
Egypt	4101.956	6.190
United Kingdom	391.360	14.908
Canada	1323.470	18.796
India	3736.322	15.618
Germany	3288.252	22.483
Malaysia	5626.971	19.250
China	5429.439	20.713
France	2323.919	29.675
Pakistan	4164.529	27.526
Australia	2844.585	31.011
Italy	4472.622	37.460
Turkey	4380.037	42.410
Spain	4961.639	43.756
South Korea	5224.229	44.260

5.3 Research Collaboration across Academic Disciplines

In Table 9, we distributed the research publications of GCC countries with the top fifteen countries for the period 2004-2013. This facilitated an easy analysis of academic fields in which these collaborations occurred and the reason(s) behind it. More than 65% of collaborative activities were in the physical science discipline. US, Egypt, UK, and Canada were the top collaborative countries (17%, 14%, 7.5%, and 6.3% respectively). Life sciences were the second collaborative field with 24.2% and again, US, Egypt, UK, and Canada were the top collaborators (6.2%, 6.8%, 3.7%, and 1.6% respectively). The probable explanation is that most science related researchers either come from or obtained their degrees from these countries. The least collaborative academic discipline was social sciences and humanities, with 8.7%. One explanation for such decimal performance is the use of Arabic as a medium of instruction in

the humanities and social science disciplines and also most of the collaborative researches are published in Arabic which is not listed in Scopus. Thus, our analysis of collaboration across disciplines supports the previous literature and proposition 3, which states that international research collaboration happened mainly in basic science fields.

Table 9: Discipline-Wise Publications' Distribution of International Scientific Collaboration of GCC Countries with the Top Fifteen Countries

	Health Sciences	Life Sciences	Physical Sciences	Social Sciences & Humanities
United States	3677	3035	8262	1409
Egypt	436	3294	6780	527
United Kingdom	98	1793	3662	809
Canada	1525	821	3072	448
India	966	1340	2826	288
Germany	1000	1139	1864	186
Malaysia	390	471	2072	287
China	302	664	1952	130
France	711	692	1799	219
Pakistan	560	601	1546	158
Australia	742	969	1371	437
Italy	632	443	869	77
Turkey	308	255	1097	98
Spain	384	333	792	77
South Korea	145	233	1011	72
Total	**11615**	**11766**	**31641**	**4252**

Source: Elsevier B.V. SciVal (2014), a registered trademark of Elsevier Properties.

Further, we adopted the International Collaborative Index (ICI) to analyse the collaboration between GCC countries and their top fifteen collaborators. The ICI has been used in the examination of many collaborative studies (He, 2009), especially when the researcher needs to calculate the proportional publications' output of international collaboration (He, 2009). For the purpose of our study, we followed the formula below:

$ICI = (I_{ii} / I_{it}) / (I_{gi} / I_{gt})$

In the above formula, Iii represents the amount of publications of GCC countries with the country in a specific field each time. I_{it} identifies the amount of publications of GCC countries with the country i in all fields. I_{gi} is the amount of publications of GCC countries with the top fifteen countries in a specific field, whereas I_{gt} is the amount of publications of GCC countries with the top fifteen countries in all fields. Table 10 below illustrates the ICI of GCC countries with the top fifteen collaborative countries in all disciplines. UK had the highest collaborative effort with GCC in life sciences, and social science and humanities, but had the lowest collaborative efforts in health sciences. Italy had the highest collaboration effort in health sciences and the lowest in social science and humanities. South Korea had the highest collaboration in physical sciences. Australia and Canada are the lowest in physical sciences and life sciences respectively. For country-wise level, the GCC and the US have the highest collaboration in social sciences and humanities and the lowest in life sciences. Egypt had the highest collaboration effort with GCC in life sciences and lowest in social sciences and humanities. In a nutshell, research collaboration between GCC countries and the collaborating countries are mostly concentrated in the science disciplines (proposition 3).

Table 10: ICI of Scientific Collaboration between GCC Countries and their Top Fifteen Countries

Fields	USA	Egypt	UK	Canada	India	Germany	Malaysia	China	France	Pakistan	Australia	Italy	Turkey	Spain	South Korea
Health Sciences	1.15	0.95	0.08	1.33	0.91	1.22	0.62	0.51	1.06	1.00	1.08	1.60	0.89	1.24	0.51
Life Sciences	0.93	1.27	1.42	0.71	1.25	1.37	0.74	1.10	1.02	1.06	1.39	1.10	0.73	1.06	0.80
Physical Sciences	0.94	0.97	1.08	0.98	0.98	0.83	1.21	1.20	0.99	1.01	0.73	0.81	1.17	0.94	1.30
Social Sciences & Humanities	1.20	0.56	1.77	1.06	0.74	0.62	1.24	0.59	0.89	0.77	1.73	0.53	0.78	0.68	0.69

Source: Authors' construct

6. Concluding Remarks

The paper sought to review international research collaborations in the GCC countries. We analysed 105,974 research publications emanating from GCC that had a form of collaboration with her Top 15 Collaborating countries and published in the Scopus database during 2004-2013. The study revealed 15.6% annual growth rate of GCC publication. While some member countries annual growth rates are higher (KSA and Qatar having 21.8% and 18.7% respectively), others are lower (UAE 12.8%, Oman 10.4%, and Kuwait 5.4%). Fifty-six and half percent (56.5%) of GCC publications were produced by or with KSA research institutions while the remaining 43.5% were produced by or with other research institutions at other GCC countries. Fifty-five percent (55%) of total GCC publications were from international collaborations and 46% (48,662 out of 105,974) were with the top fifteen research collaborating countries. Within the period of study, total research output of international collaborations increased from 38% in 2004 to 65% in 2013, with an exponential annual growth rate of 23.2%.

These results represented the genuine collaborative researches between GCC countries and their top 15 counterpart countries published in international reviewed journals. The analyses obtained can therefore serve as a baseline data for future evaluation as well as for comparative purposes with other collaborative research in non-GCC countries. These notwithstanding, the study had some inherent limitations especially with the methodology. For instance bibliometric analysis have been criticised severely especially pertaining to the role and level of contribution of each author in a co-authored paper. Data were obtained from SCOPUS neglecting other publications falling outside this terrain including those that are either delayed or never get published. Furthermore, some articles on research collaborations might have been published in Arabic and therefore had limited coverage in peer reviewed international journals. Nonetheless, it has become a standard practice in scientific research to use bibliometric indicators because it is relatively convenient due to the availability and accuracy of data. This finding has also not taken into account the hindrances of the social interdependence theory as well as international research collaborations conducted in Arabic between the GCC countries.

Given the high investments in R&D in most of the GCC countries, we suggest the region could develop different strategies to encourage international collaboration, especially with developed countries in order to fully utilize the available resources at regional level and across the globe. This will improve research quality and productivity at either the researchers' level or at the national or regional levels. Mostly, international research collaboration ensue

in basic research and countries with low research productivity have more international collaborations (Katz, 2000; Davidson Frame and Carpenter, 1979). Policy-makers in the region could foster intra-regional collaboration especially between the publicly-funded universities to enhance their research productivity and share resources and infrastructure as well. This will further have a positive impact on the quality and productivity of research output in the region.

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